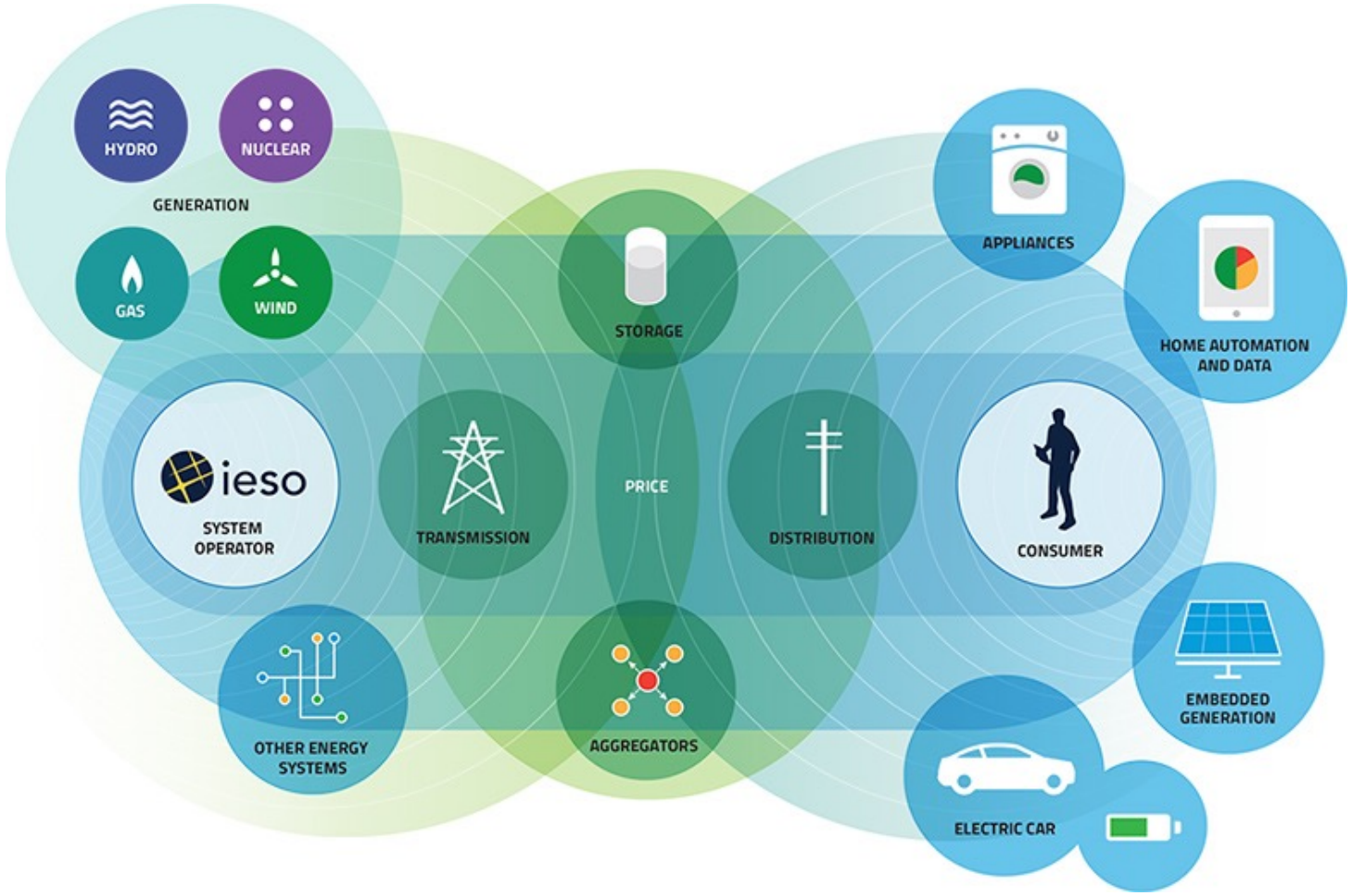
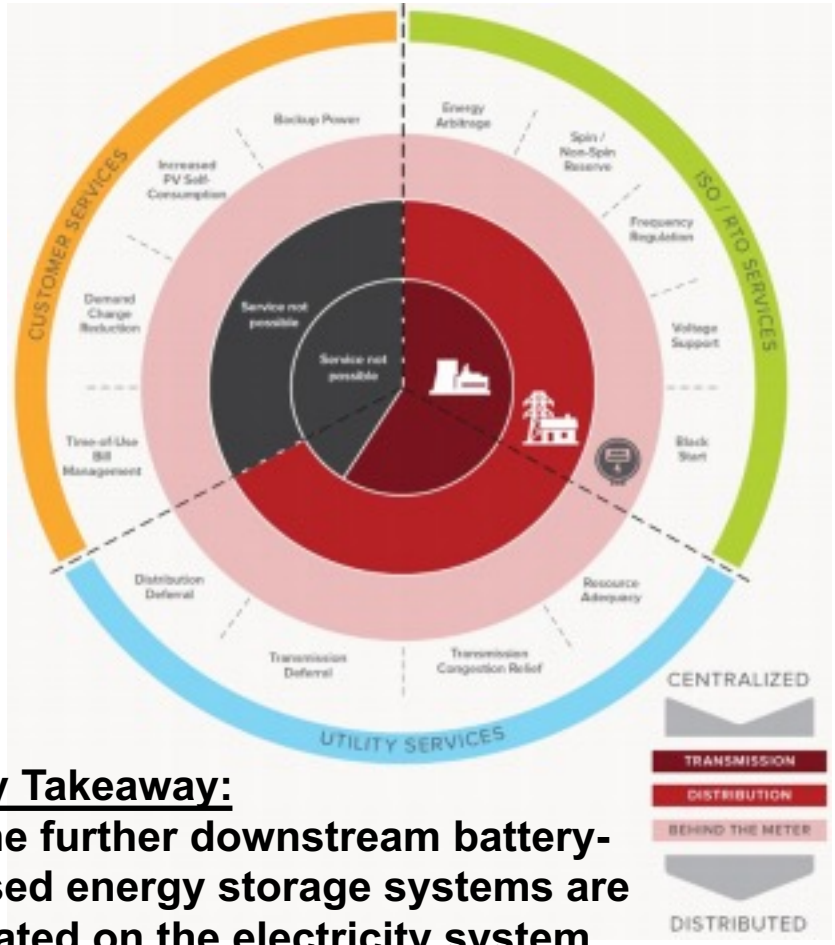
DER Case Studies in Ontario



July 2021
Presentation to OEB FEI Working Group
Geoff Osborne, Director, Strategy & Operations

Unlocking Potential: An Economic Valuation of Storage in Ontario (ESC)

- …Over the next decade, this report shows that the introduction of at least 1,000 MW of energy storage can provide as much as $2.7 billion in total savings for Ontario's electricity customers, and that the savings could reach upwards of $4 billion.
- In large part, these savings are a direct result of more efficient utilization of the province's long-term generation assets, many of which were added to the system over the last decade or are currently being refurbished for the coming decades. From a net savings perspective, based on an installed cost of $200,000 per MW per year, energy storage can provide $774 million to $2 billion in savings under a base case and a high estimate case, respectively.
- The potential savings from energy storage are categorized into three service types:
  - **Wholesale Market**: Energy storage can provide a range of wholesale market savings, including energy arbitrage, reduced prevalence of Surplus Baseload Generation, reduced need for flexibility and cost-guarantee procurement mechanisms, lower ancillary service costs, and increased participation in Capacity Auctions. In total, energy storage can provide $1.1 billion to $3.1 billion in gross savings in the wholesale market.
  - **Maximize Transmission and Distribution Investment**: Energy storage investments can be made at specific locations on the grid to better utilize existing transmission and distribution assets. Based on current power system planning outlooks and historical investment trends, energy storage can provide $457 million to $840 million in gross savings over the next decade.
  - **Direct-to-Customer Savings**: Energy storage can help electricity customers manage individual costs by shifting peak consumption, resulting in lower Time-of-Use rates and reduced demand charges. Energy storage can also help shift renewable energy output – largely from solar generators – from low-value to high-value hours.
- Energy storage can provide a number of more qualitative benefits – many of which will also produce savings, but have not been estimated as part of this report. The benefits include reduced greenhouse gas emissions, lower transmission congestion, increased electricity exports and import values and improved power quality



Key Takeaway:

"The further downstream battery-based energy storage systems are located on the electricity system, the more services they can offer to the system at large."

Case Study #1: Toronto's First Virtual Power Plant (VPP) Pilot

Key Takeaways:

- Fleet of home batteries operated as a virtual power plant to deliver affordable customer resiliency and local demand response
- Private-sector and unregulated utility ownership, along with IESO Grid Innovation funding
- Value stacking to lower-costs to all beneficiaries, resulting in roughly equal cost-sharing between IESO + Utility + Customer
- **RESULTS: DER value-stacking results in ~2/3 cost-reduction to LDC**

BRINGING AFFORDABLE RESILIENCY TO THE DOWNTOWN CORE

THE OPPORTUNITY

We are launching the first major residential battery (Tesla Powerwall) rental program in Canada in one of Canada's most densely populated and electrically congested neighbourhoods. Our project will provide affordable resiliency to homeowners while delivering much-needed local and system-wide services to reduce electricity costs and emissions while avoiding costly substation upgrade infrastructure.

We want to support Toronto's ambitious sustainability targets through an equally ambitious VPP pilot project.

BENFITS OF ENERGY STORAGE

Homeowners

- **Increased Resiliency:** Onsite storage improves power quality and better protects essential systems.
- **Peak Energy Cost Reductions:** Optimizing local energy consumption based on TOU price signals reduces peak energy charges to customers.

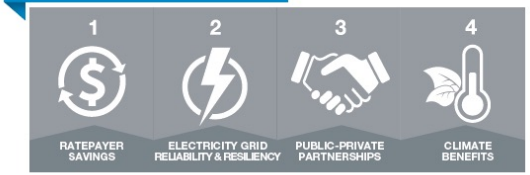
Toronto Hydro & City of Toronto

- **Utility Benefits:** Toronto Hydro will be able to better manage peak demand and defer conventional infrastructure costs, while improving local power quality & resiliency.
- **TransformTO Goals:** This project directly supports the City's TransformTO storage and climate objectives.

Ontario's Independent Electricity System Operator

- **System Services:** Energy storage can deliver system services including DR, OR, etc.
- **DER Test Services:** The microgrid can deliver new IESO DER services including ramping, transactive energy, etc.

BENEFITS FOR TORONTO



COST-EFFECTIVE, QUICK DEPLOYMENT

The Tesla Powerwall is a rechargeable lithium-ion home battery that optimizes energy usage. Homeowners living in the service area (below) are eligible to rent a Tesla Powerwall for **$29.99/month**, plus a one-time connection charge of **$1,500**, representing a >50 lifecycle cost savings compared to a standard direct system purchase.

STRATEGIC SITING: ELIGIBLE ZONE

Energy storage can be strategically sited to deliver a combination of local and system-wide benefits.

Our project will aggregate a "fleet" of Tesla Powerwall units connected to the Cecil street substation to act as a decentralized battery. Customers located in the Spadina and College area of Toronto will be eligible to participate in this program (subject to additional pilot terms and conditions):

GOVERNMENT PRIORITY

"Our government is building an electricity system that works for the people,.. We are taking a comprehensive, pragmatic approach to building the modern, efficient, and transparent electricity system that the people of Ontario deserve".

– Hon. Rod Phillips, MoECP

ABOUT NRSTOR INC.

NRStor is an industry-leading energy storage project developer. We provide innovative solutions based on our unparalleled understanding of energy storage technologies, their costs, and the benefits they can provide.

We have earned our reputation as a leader in energy storage. NRStor built the first commercial flywheel storage project in Canada and is now building the first commercial fuel-free compressed air energy storage project in the world. We have over 100MW of lithium ion battery projects in development and a growing pipeline of exciting innovative projects.

A CONSORTIUM THAT CAN EXECUTE

- **NRStor:** Battery developer/owner, commercial ops. manager
- **MPOWER:** Canada's certified installer of the Tesla Powerwall
- **Enbridge Gas:** Utility integration and overall program growth
- **Toronto Hydro & City of Toronto:** Utility connection and integration
- **Tesla Energy:** Tesla Powerwall supplier and aggregation platform

TESLA POWERWALL FUNCTIONALITY

- Save on energy during on-peak hours
- Receive alerts in the event of a power outage
- Rely on a 12 to 24-hour backup power supply for your essential appliances and devices in your home
- Monitor your home energy use in real-time on your phone from anywhere

Control Your Energy from Anywhere

Seamlessly monitor and automatically manage your Powerwall, solar panels, Model S or X anytime, anywhere with the Tesla App.

PROJECT PARTNERS

ENBRIDGE · MPOWER · TESLA ENERGY · TORONTO HYDRO · NRSTOR INC.

Case Study #2 & #3: Alectra Power.House Study & GMP Pilots

Key Takeaways (Alectra):

- Power.House solar+storage pilot in York-Region
- Identified customer + utility + system benefits for DERs and market opportunity

Key Takeaways (GMP in Vermont):

- Home battery pilot for local congestion needs (NWA)
- Highlights the success of both BYOD (customer-owned) and customer lease (utility-owned) models

Table 1. Feasibility Study Archetype Program Offer

Single family home:

- $4,500 per unit up-front
- $80/month for 10 years
- Payback between 4 and 5 years

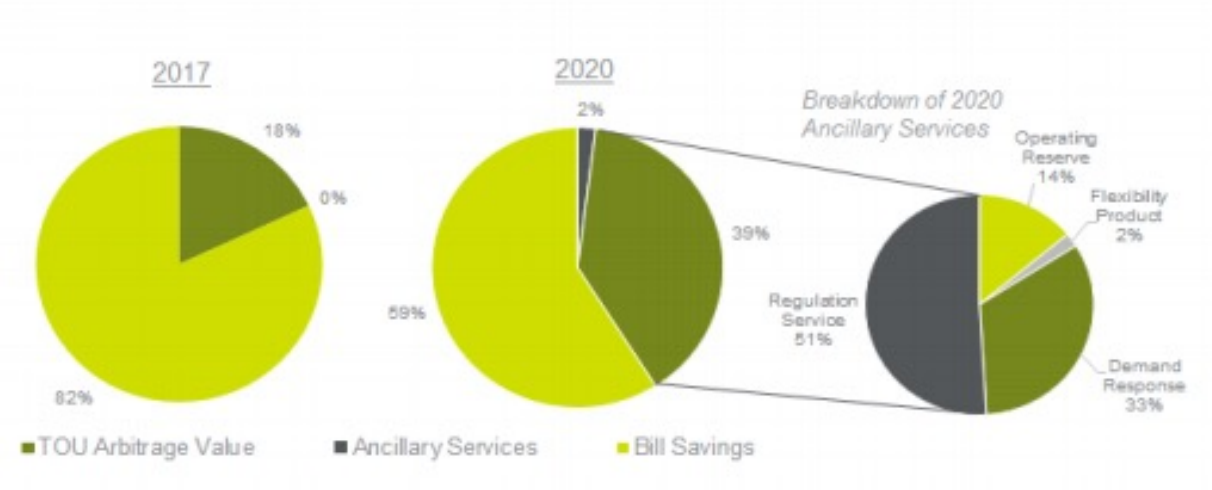
Semi-detached/row home:

- $3,400 per unit up-front
- $55/month for 10 years
- Payback between 5 and 6 years

Figure 6. Modeling Approach

Modeling Approach		Sources of Benefits
CUSTOMER	Using historical average solar generation and customer consumption for single family and semi/row homes, determined the customer's consumption and calculated the electricity bill before and after installation of the POWER.HOUSE system.	• Solar generation offsetting electricity consumption on-peak with net metering • TOU arbitrage (purchasing electricity off-peak to charge the storage and using the storage during on-peak hours) • Outage support
UTILITY	Built upon the technical characteristics of storage, rules and logic were determined to produce an optimal and realistic dispatch of the POWER.HOUSE systems. Existing and forecast prices for ancillary and market services were used to calculate a monetary value over the study period.	• Participation in existing ancillary and market services (regulation service, operating reserve, and demand response) • Potential future market services enabled by the fast response abilities of POWER.HOUSE
SYSTEM	Analysis compared the anticipated system needs and POWER.HOUSE adoption. The number of years of deferral determined the potential value. Avoided emissions were calculated by evaluating when emitting resources would be producing.	• Ability to defer a transmission and/or distribution upgrade by certain number of years • Avoided Greenhouse Gas (GHG) emissions

Figure 8. Proportionate Value



The Study of Energy Storage in Ontario Distribution Systems

Currently Monetizable Benefits	Distribution Connected Energy Storage Location[1]			
	At TS	Middle of Feeder	End of Feeder	Behind Meter
Market Arbitrage	✓	✓	✓	✓
Distribution System Upgrade Avoidance	✓	✓	✓	✗
New Generation Capacity Avoidance	✓	✓	✓	✗
Redundant Power Supply (Reliability)	✓	✓	✓	✓
Non-Spinning Reserve Availability	✓	✗	✗	✗
Spinning Reserve Availability	✓	✗	✗	✗
Reserve Activation	✓	✗	✗	✗
Power Quality Improvement	✓	✓	✓	✓
Frequency Regulation	✓	✓	✓	✗
Voltage Control	✗	✓	✓	✗
Black Start	✓	✓	✗	✗
Reduce Dispatching of Peaker Facilities	✓	✓	✓	✓
Global Adjustment Charge Reduction (Class A)	✗	✗	✗	✓

Table 4: Direct Benefit Matrix

Benefit	Monetary Range ($ per MWh Delivered)	Assumed Number of MWh per year	Total $ Per Year
Market Arbitrage	$13.90 -$23.50	1460	$20,294 - $34,310
Distribution System Upgrade Avoidance	$12.87 -$133.56	1460	$18,790 - $194,998
New Generation Capacity Avoidance	$12.15 -$25.23	1460	$17,739 - $36,836
Redundant Power Supply (Reliability)	$3,900 -$26,000	10	$39,000 - $260,000
Non-Spinning Reserve Availability	$0.20 - $30	1460	$292 - $43,800
Spinning Reserve Availability	$0.20 - $54	1460	$292 - $78,840
Reserve Activation	$0.40 - $135	730	$292 - $98,550
Power Quality Improvement	$6.06 -$11.35	3025	$18,332 - $34,334
Frequency Regulation	$45 - $65	3025	$136,125 - $196,625
Voltage Control	$8.30 - $58.50	3025	$20,294 - $34,310
Black Start	$5.85 - $36	10	$58.50 - $360
Reduced Dispatching of Peaker Facilities	$110 - $170	1460	$160,000 - $248,200
Global Adjustment Charge Reduction (Class A)	$80,000-$105,000	5	$400,000 - $559,310

Table 2: Currently Monetizable Benefits, from Appendix A, Value Matrix

Key Takeaway:

An Ontario LDC (Essex) has assessed various technical and financial impacts of DERs (storage) on their system, identifying multiple value-creation opportunities

Ontario DER Value Stacking Potential

Key Takeaways:

- **DERs can provide a wide array of benefits from customers to the utility to the wholesale market**
- **The ability for DERs to "stack" multiple services simultaneously is less understood, but represents the biggest opportunity for cost-savings and wide-scale adoption**
- **DER ownership dictates the primary use-cases**
- **Regulatory barriers (uneven playing field) remains the largest barrier to DER adoption**

Service	Service Type	Counterparty	BTM DER	FTM DER
Energy Arbitrage	Energy Market	IESO	YES	YES
Renewables Optimization	Energy Market / Other	IESO / Renewable Generator	MAYBE	Only applicable if "virtual" aggregation is possible
Operating Reserve	Capacity Product	IESO	NO	If >1MW
Capacity/DR Auction	Capacity Product	IESO	If >1MW	If >1MW
Reliability Must Run	Ancillary Service	IESO	NO	NO
Reactive Support & Voltage Control (RSVC)	Ancillary Service	IESO	NO	NO
Regulation Service	Ancillary Service	IESO	If >1MW	If >1MW
Other Programs (eg. Transactive Energy, Ramping, OR)	DER Test Cases	IESO	WHERE APPLICABLE	WHERE APPLICABLE
Non-Wires Alternative (eg. Tx capital savings)	Non-Wires Alternative (NWA)	Transmission Utility (eg. HONI)	YES	YES
Non-Wires Alternative (eg. Dx capital savings)	Non-Wires Alternative (NWA)	Distribution Utility	YES	YES
Congestion / Tx Demand Charge Management	Capacity Product (eg. Local Demand Response)	Distribution Utility	YES	YES
Feeder Power Quality (SAIDI)	Reliability	Distribution Utility	YES	YES
Other Utility Programs	Other	Transmission or Distribution Utility	WHERE APPLICABLE	WHERE APPLICABLE
Global Adjustment Reduction	Capacity Product (eg. ICI Program)	Customer (Class A / B)	If >500kW	Only applicable if "virtual" aggregation is possible
TOU Energy Savings	TOU Energy	Customer (Residential)	YES	
Power Quality	Reliability	Customer	YES	
Customer Net Metering	TOU Energy	Customer	YES	
GHG Savings (Optimized/Deferred Assets)	Indirect Benefit	Customer / IESO / Ontario	YES	

LDC FOCUS